SENSORS & CONTROLS

Project Fact Sheet

Sensor Fusion for Intelligent Process Control

Benefits

- A reduction of 5 percent in energy usage of glass melting furnaces through combustion and heat transfer optimization, equivalent to a 0.015 Quad Btu per year savings
- An increase in the flat glass production yield of 5 percent from better product uniformity, contributing to another 0.015 Quad Btu savings
- Reductions in emissions of 12 million tons per year of CO_2 and 110,000 tons per year of SO_2, associated with the cumulative decrease of 0.03 Quad Btu per year of energy consumption

Applications

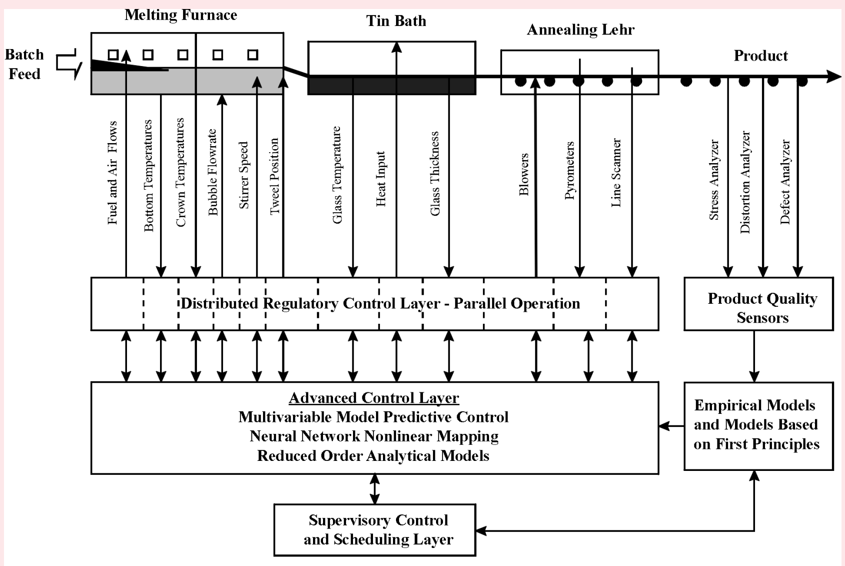
The architecture of the control system and its software components will be generic and adaptable to hierarchical control of a wide range of types of manufacturing processes. The technology will be suited for application to any complex, multi-step processes that during raw material transformation to finished products involve widely varying conditions, nonlinear behavior, and slow output response to changing input conditions. In addition to its primary target use in flat glass production, such advanced process control technology is also described as a need in technology roadmaps for other industries, including aluminum, chemical, forest products, metalcasting, and steel.

Fusion of sensors for production control will minimize product defects arising from imperfect control of process conditions

The sensor fusion for intelligent process control will integrate the information from on-line process and product quality sensors to achieve end-to-end digital control of production. The control system will span the full range of a production facility, from the input of raw and recycled materials to the output end of the product line. Today, this span is covered by independent, non-communicating sets of sensors and control subsystems, including human operators stationed along the production line to make decisions. By employing fusion of the diverse sensors and the expert systems for the capture of human skills, improved energy efficiency, improved productivity, longer furnace campaigns, and a reduction of combustion-generated pollutants could be achieved.

Because of the relatively low cost of computers and electronic components, the control systems would be cost effective to all sizes of furnaces where there are, or could be, on-line measurements of product quality. The glass melting furnaces alone may number in the hundreds.

Sensor Fusion



Distributed and hierarchical control of flat glass production (equipment schematic after Sewell, 1997).

Project Description

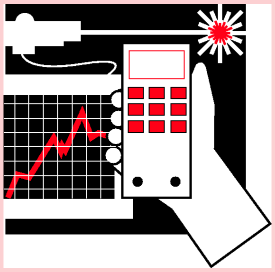
Goal: Develop and implement the optimum sensing and control strategy on a production furnace to achieve improvement of 10 percent in energy efficiency with an ultimate goal of minimizing all types of product defects.

The sensor and control system will consist of stand-alone sensors and a hierarchy of control software. The specific emphasis of this project is the linkage of glass quality to batch preparation, melting, fining, conditioning, forming, and annealing processes, and the reduction of defects arising from less-than-optimum control of composition, temperatures, melt circulation, viscosity, and thickness. The scope involves identifying the appropriate product and process sensors, linking the sensors to the control system, and relating the product parameters to the process parameters. The fusion of diverse sensors will be achieved through use of correlation functions connecting inputs and outputs of subsystems, expert systems for the capture of human skills, and physics-based, high-fidelity digital simulation used in model-predictive control.

A hierarchical control system will be developed to consist of three layers: (1) distributed parallel regulatory controls involving data acquisition and localized feedback control strategies, (2) advanced model-based and neural network controllers using input from the regulatory control system to anticipate the appearance of defects and move to prevent their occurrence, and (3) supervisory control and scheduling to provide visual aids to allow monitoring of operational trends over time. One layer will be implemented in each of the three years of the project, culminating in implementation of the sensor and control system on a Visteon product line.

Progress and Milestones

- This project was selected through the Sensors and Controls Program FY99 solicitation and was awarded in January 1999. All tasks are scheduled for completion in 36 months and are structured in three 12-month phases, with review after each phase for decision on continuation.
- By December 1999, complete development and implementation of distributed parallel regulatory controls, including establishing baseline performance, installing sensors to record transient system performance, and implementing local feedback loops.
- By December 2000, complete development and implementation of advanced model-based and neural network controllers, assembling a high-fidelity model for combustion space/batch blanket/molten glass simulation, a multivariable model predictive control, the neural network mapping, and a fuzzy logic scheme.
- By December 2001, assemble the supervisory system and interface with all other components of the control system in the plant, make quantitative evaluations of the improvements in efficiency and yield achieved through process control, and run the high-fidelity simulations to achieve process simulations.
- By January 2002, a prototype system will be fully operational on a Visteon production line. Installations on one or two additional Visteon production lines will be made by the end of January 2003, and the refined system will be placed on the market in January 2004.



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